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IMPROVEMENT OF RAW MATERIALS PREPARATION BY MEANS OF ACTIVATION PROCESSES IN CERAMICS TECHNOLOGY

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The techniques examined in this article for controlling the structure and properties of materials and obtaining intermediate products make it possible to standardize individual features of even low-quality raw materials and increase the quality of the final product.

As a result of the disordering of the crystal structure of clay raw materials their rheological properties are unstable and the formation process is more complicated [1]. It is precisely the preparation of clay that often determines the quality of the finished ceramic product. For example, in ancient China kaolins were placed in holes in the ground to age for decades and only after this aging period were they used to produce the best porcelain in the world. In Europe the system used to prepare clay made it possible to produce tiles which have a long life time. Elements of these technologies are still used today. All techniques for preparing ceramic raw material are based on stabilizing the properties of the raw material, and hence the change in the structure and texture of the materials, or on activation processes.

The technological techniques for stabilizing or activating the phases of ceramic raw materials can be divided into two groups [1]:

techniques which promote the removal of excess stresses in the material, decrease of the concentration of nonequilibrium defects, and ultimately stabilization of the structure and properties of the initial raw materials;

activation techniques that increase the concentration of defects with nonequilibrium structure and produce materials with high reactivity.

Techniques for stabilizing clay raw materials such as natural processing, mechanical action, and treatment with steam and silicate bacteria are distinguished by a low rate of structural changes. The most effective method could become hydrothermal modification of clays, which rapidly (within several tens of minutes) stabilizes and orders the structure, yielding a structure that is comparable to that obtained after months and year of natural processing [2]. In addition, steaming makes it possible to decrease by almost an order of magnitude the interaction energy between particles in suspensions and, in consequence, obtain casting slips with high fluidity without using electrolytes and eliminate slip aging from the technological process. In this process, the outflow time and yield stresses decrease substantially (Fig. 1).

The introduction of hydrothermally modified clay materials into the casting suspension results in the formation of a high-quality intermediate product and increases the density of the casting. This is confirmed by photomicrographs of dry samples, obtained from suspensions of kaolins from the Prosyanovskoe and Zhuravlinyi Log deposits, before and after hydrothermal treatment (Fig. 2).

The high quality of the intermediate product containing stabilized clays allows the calcination process to proceed for uniformly and, in consequence, obtain a defect-free, dense, and strong structure in sanitary ware and technical articles.

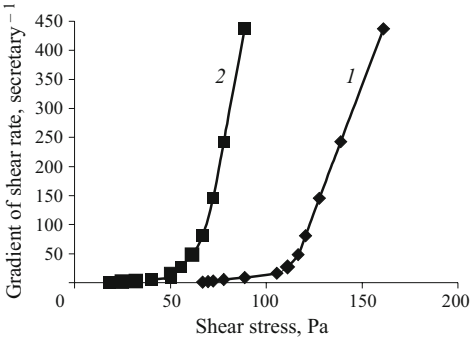

Fig. 1. Rheological characteristics of porcelain-faience slips with moisture content 32% of the initial composition (*1*) and composition with hydrothermally modified clay material (*2*).

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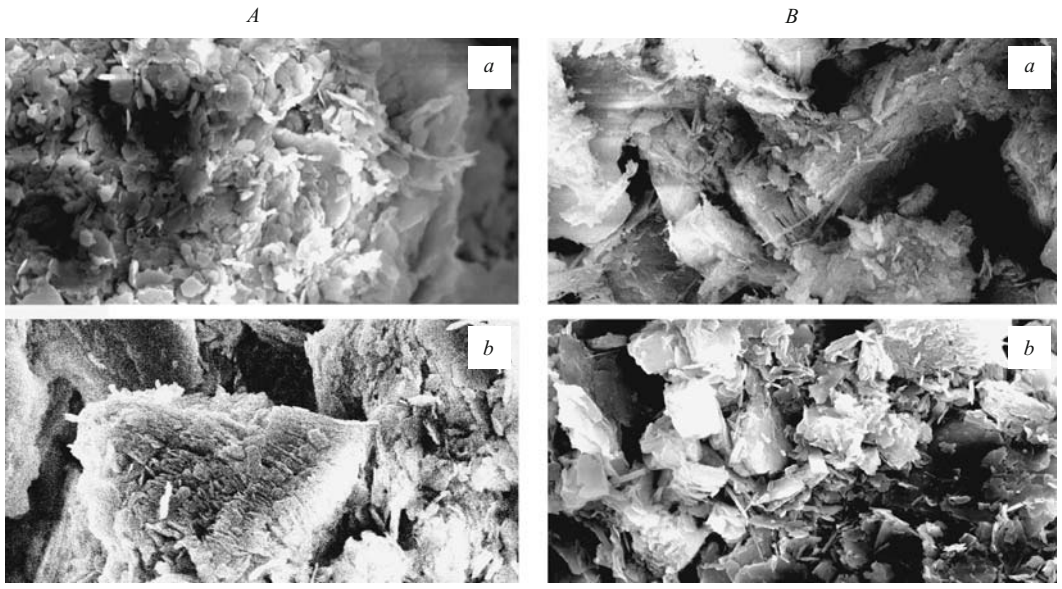

Fig. 2. Microstructure of a casting from Prosyanovskoe (*A*) and Zhuravlinyi Log (*B*) kaolin (× 15,000): *a*) initial; *b*) after hydrothermal treatment.

The physical – mechanical properties of ceramic samples containing unprocessed clay raw material (composition *1*) and hydrothermally modified clays and kaolins (composition *2*) are presented in Table 1. Evidently, preliminary hydrothermal treatment makes it possible to use up 20% unprocessed Zhuravlinyi Log kaolin in porcelain-faience mixes.

In summary, the technological techniques indicated above make it possible to correct certain structural imperfections of the raw material and thereby form purposefully the required properties of clay.

However, a fundamentally different approach is also possible. In this approach the phase composition of the raw material is altered and artificial ceramic binders with prescribed constant properties are produced.

Thus, together with activation techniques, it was proposed that elements of the technology of highly concentrated binding suspensions (HCBS) be used in the production of porcelain-faience materials [3]. In this case, the properties of the natural material are changed by preliminary heat-treatment of the initial paste. This approach makes it possible not only to use low-quality clays and kaolins but also, in a number of cases, to decrease the number of components in the pastes. The preliminary treatment at temperatures up to 1000°C predetermines the large structural changes occurring in material as well as the activation of the material by means of dehydration reactions of the clay components, polymorphism of quartz, and so forth. The subsequent milling of activated initial pastes by the HCBS technology makes it possible to obtain porcelain slips which possess binding properties and have a high concentration of a solid phase together with plasticity (Table 2).

Castings based on artificial ceramic binders differ by a closer, ordered packing (Fig. 3). This is reflected in the subsequent operations and calcination and makes it possible to obtain articles with low shrinkage and higher quality.

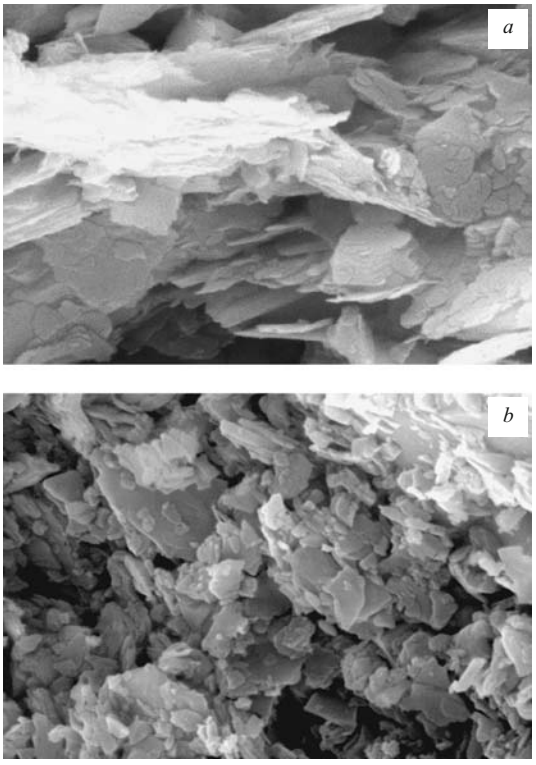

Fig. 3. Microstructure of samples of factor slip (*a*) and artificial ceramic binders (*b*).

TABLE 1.

Composition	Hydrothermal treatment	Total shrinkage, %	Density kg/m^3	Water saturation, %	Compression strength, MPa
1	No	5	2290	1.1	86
2	Yes	5	2330	0.6	151

TABLE 2.

Indicator	Factory slip	Artificial ceramic binders
Density, kg/m^3	1740	1950
Thickening factor	1.4	1.1
Moisture content, %	31	16
Casting density, kg/m^3	1690	1930

This technology, which is associated with the production of thermally activated chamotte, could become especially effective in centralized preparation of raw materials. In this case the works producing porcelain-faience articles can do away with the preparation of the conventional casting slips according to individual technologies and switch to using activated intermediate products with uniform properties. This will increase the stability of the technological process.

In summary, the techniques examined above for controlling the structure and properties of materials and obtaining intermediate products makes it possible to standardize the individual features of even low-quality initial material and increase the quality of the final product.

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